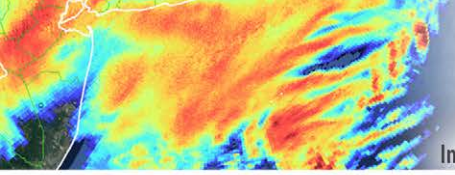

# IMPACTS

Investigation of Microphysics and Precipitation for Atlantic Coast-Threatening Snowstorms

**IMPACTS will determine how multi-scale dynamical and microphysical processes in winter storms interact to produce banded regions of snowfall, and will provide knowledge that informs remote sensing of snow from space and improves US storm prediction capabilities.**

## 1.0 EXECUTIVE SUMMARY

Winter snowstorms are frequent on the eastern seaboard, where a large percentage of the US population lives, and cause major disruptions to transportation, commerce, and public safety. Snowfall within these storms is frequently organized in banded structures that are poorly understood by scientists and poorly predicted by current numerical models. Despite this, no major study of East Coast US snowstorms has occurred over the last 30 years (**Table 1-1**). Since that last study, the capabilities of remote sensing technologies and numerical weather prediction models have advanced significantly, making now an ideal time to conduct a well-equipped snowstorm study to identify key processes and improve remote sensing and forecasting of snowfall.

**Table 1-1:** IMPACTS is the first mission with a full suite of modern instrumentation to specifically focus on disruptive East Coast US snowfall and winter storms.

| *Campaign* | IMPACTS 2020 | OLYMPEX 2015 | GCPEX 2012 | PLOWS 2009-10 | IMPROVE 2001 | GALE 1986 |
|---|---|---|---|---|---|---|
| *Region* | East Coast | West Coast | North | Central | West Coast | East Coast |
| *OperationalModel Resolution* | *1-2 km* | *1-4 km* | *5-15 km* | *10-20 km* | *15-25 km* | *50 km* |
| X-band radar | ● | ● | | | ● | ● |
| Ka-band radar | ● | ● | ● | | | |
| Ku-band radar | ● | ● | ● | | | |
| W-band radar | ● | ● | | ● | | |
| 10-85 GHz PMW | ● | ● | | | | |
| 50-183 GHz PMW | ● | ● | ● | ● | | |
| Cloud Lidar | ● | ● | | | | |
| Microphysics | ● | ● | ● | ● | ● | ● |
| Soundings | ● | ● | ● | ● | ● | ● |
| Ground Meas. | ● | ● | ● | ● | ● | ● |

OLYMPEX=The Olympic Mountains Experiment, GCPEX=GPM (Global Precipitation Measurement) Cold-season Precipitation Experiment, PLOWS=Profiling of Winter Storms, IMPROVE=Improvement of Microphysical Parameterization Through Observational Verification Experiment, GALE=Genesis of Atlantic Lows Experiment.

The Investigation of Microphysics and Precipitation for Atlantic Coast-Threatening Snowstorms (IMPACTS) will fly a complementary suite of remote sensing and *in-situ* instruments for three 6-week deployments on the ER-2 and P-3 aircraft. IMPACTS will address three specific objectives (**Figure 1-1**), providing observations critical to understanding the mechanisms of snowband formation, organization, and evolution (**Figure 1-2**). IMPACTS will also examine how the microphysical characteristics and likely growth mechanisms of snow particles vary across snowbands. ***IMPACTS will improve snowfall remote sensing interpretation and modeling to significantly advance predictive capabilities.***

IMPACTS addresses the NASA Earth Science Enterprise science goal to study Earth to advance scientific understanding and meet societal needs, and the NASA Weather Focus Area's research objective to "enable improved predictive capability for weather and extreme weather events." IMPACTS is also relevant to the Global Precipitation Measurement (GPM) and CloudSat missions, and the National Academies recommendation for a designated program focused on clouds, convection, and precipitation.

IMPACTS collects data from a "satellite-simulating" ER-2 and *in-situ* measurements from a cloud-penetrating P-3, augmented by ground-based radar and rawinsonde data, multiple NASA and NOAA satellites [including GPM , GOES-16, and the Joint Polar Satellite System (JPSS)], and computer simulations. The ER-2 and P-3 provide the flight-altitude and long-endurance capabilities and payload capacity needed for the combined remote sensing and *in-situ* measurements.

The IMPACTS airborne instrument suite (**Table 1-2**) provides a synergistic range of measurements for snow process studies. It combines advanced radar, lidar, and microwave radiometer remote sensing instruments on the ER-2 with state-of-the-art microphysics probes and dropsonde capabilities on the P-3 to sample US East Coast

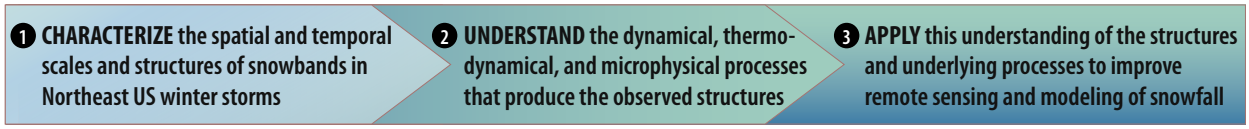


**Figure 1-1:** The IMPACTS objectives meet NASA's Earth Science goals and address the 2017 Decadal Survey targeted observable for clouds, convection, and precipitation.

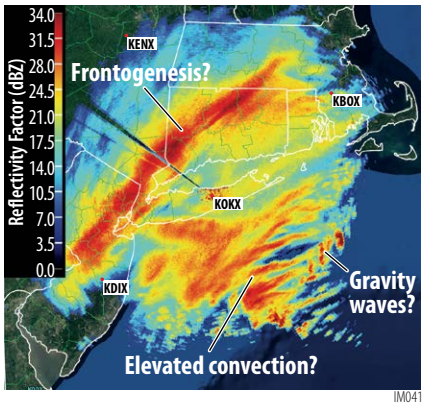


**Figure 1-2:** Snowfall in Northeast cyclones is organized in linear structures of unknown origin, possibly related to frontogenesis, gravity waves, or elevated convection. IMPACTS will determine the origins of these band-driving forces.

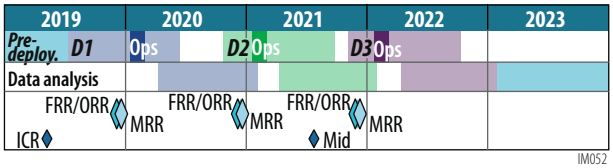


**Figure 1-4:** The IMPACTS timeline enables surveys of winter storms over multiple winters, with ample time for data analysis.

**Table 1-2:** Instruments were selected for their flight-proven capabilities and relevance to IMPACTS' science objectives.

| IMPACTS' Instrumentation | | |
|---|---|---|
| **ER-2 Aircraft: Remote Sensing Instruments** | | **Org** |
| CRS | Cloud Radar System | GSFC |
| HIWRAP | High-altitude Imaging Wind & Rain Airborne Profiler | GSFC |
| EXRAD | ER-2 X-Band Doppler Radar | GSFC |
| CoSMIR | Conical Scanning Millimeter-wave Imaging Radiometer | GSFC |
| AMPR | Advanced Microwave Precipitation Radiometer | MSFC |
| CPL | Cloud Physics Lidar | GSFC |
| **P-3 Aircraft: *in-situ* Instruments** | | **Org** |
| CDP | Cloud-Droplet Probe | UND |
| CAPS | Cloud, Aerosol and Precipitation Spectrometer | UND |
| 2D-S | 2D-S Probe | UND |
| HVPS-3 | High Volume Precipitation Sampler-3 | UND |
| Nevzorov | Nevzorov Probe | UND |
| King | King Probe | UND |
| Hawkeye | Hawkeye Probe | GSFC |
| RICE | Rosemount Icing Probe | UND |
| WISPER | Water Isotope System for Precipitation and Entrainment Research | OSU |
| TAMMS | Turbulent Air Motion Measurement System | LaRC |
| AVAPS | Advanced Vertical Atmospheric Profiling System | NCAR |

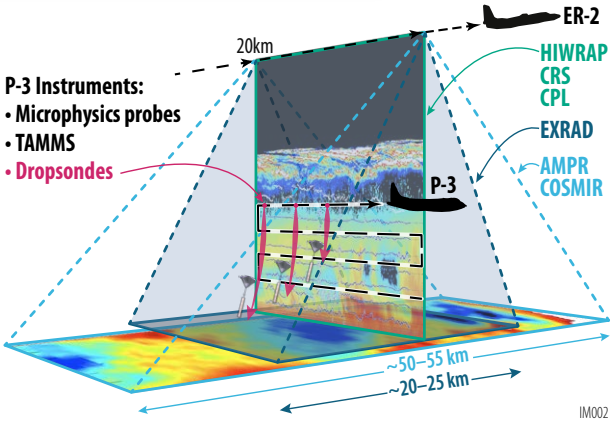


**Figure 1-3:** IMPACTS will use coordinated remote-sensing ER-2 and *in-situ* sampling P-3 flights to study the structure, dynamics, and microphysical characteristics of banded structures in winter storms. Merging ER-2 multi-sensor data (CPL, HIWRAP, and AMPR, shown above) enables advanced retrievals of microphysical properties of snowbands.

winter storms (**Figure 1-3**). By flying the two aircraft in an approximately vertically stacked coordinated pattern, with flight legs generally orthogonal to the snowband orientation, the instrument suite provides approximately collocated dynamical and microphysical measurements that advance our understanding of processes in winter storms.

The baseline mission accomplishes the three science objectives (**Figure 1-1**) using all of the instruments in **Table 1-2** during the course of three 6-week campaigns from mid-January through February 2020-2022. The threshold investigation meets all of the science objectives, but with less fidelity, through a subset of the measurement requirements. The datasets not obtained in the threshold investigation will be derived from other data sources.

IMPACTS meets the requirements for key decision point reviews, with ample time for post-deployment data analysis and modeling (**Figure 1-4**). The team plans publications describing initial results from each deployment ~1 year after each deployment; in-depth studies will be published in a special IMPACTS collection of the American Meteorological Society (AMS).

The IMPACTS schedule and budget (Total $30M, Science $15.9M) are based on heritage from similar flight campaigns. The leadership team has hands-on experience implementing investigations that rapidly and reliably disseminate groundbreaking data (OLYMPEX and HS3), and the Science Team includes key leaders in the field of winter storm research. This experience enables the IMPACTS team to anticipate and mitigate risks and ensure on-time and within-budget implementation.